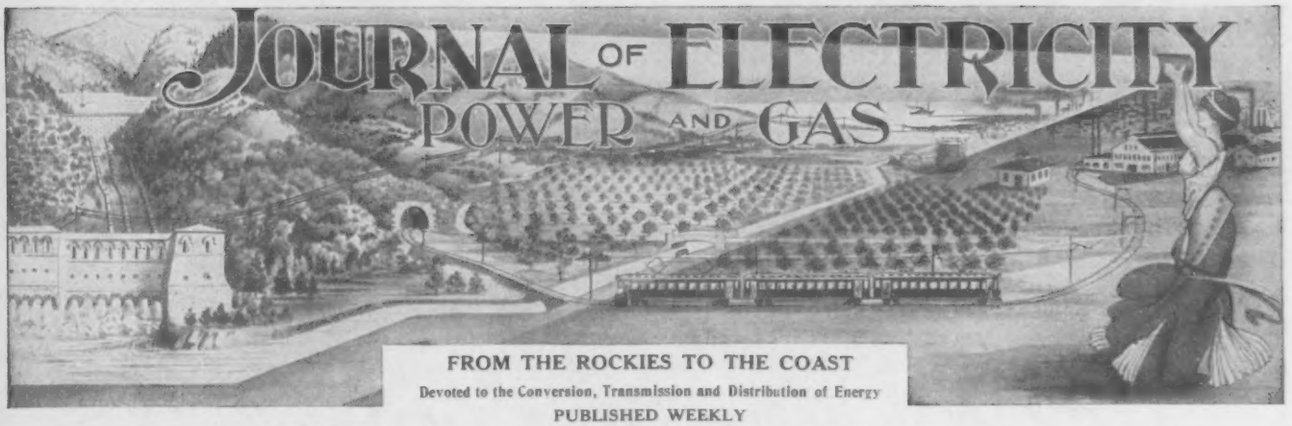
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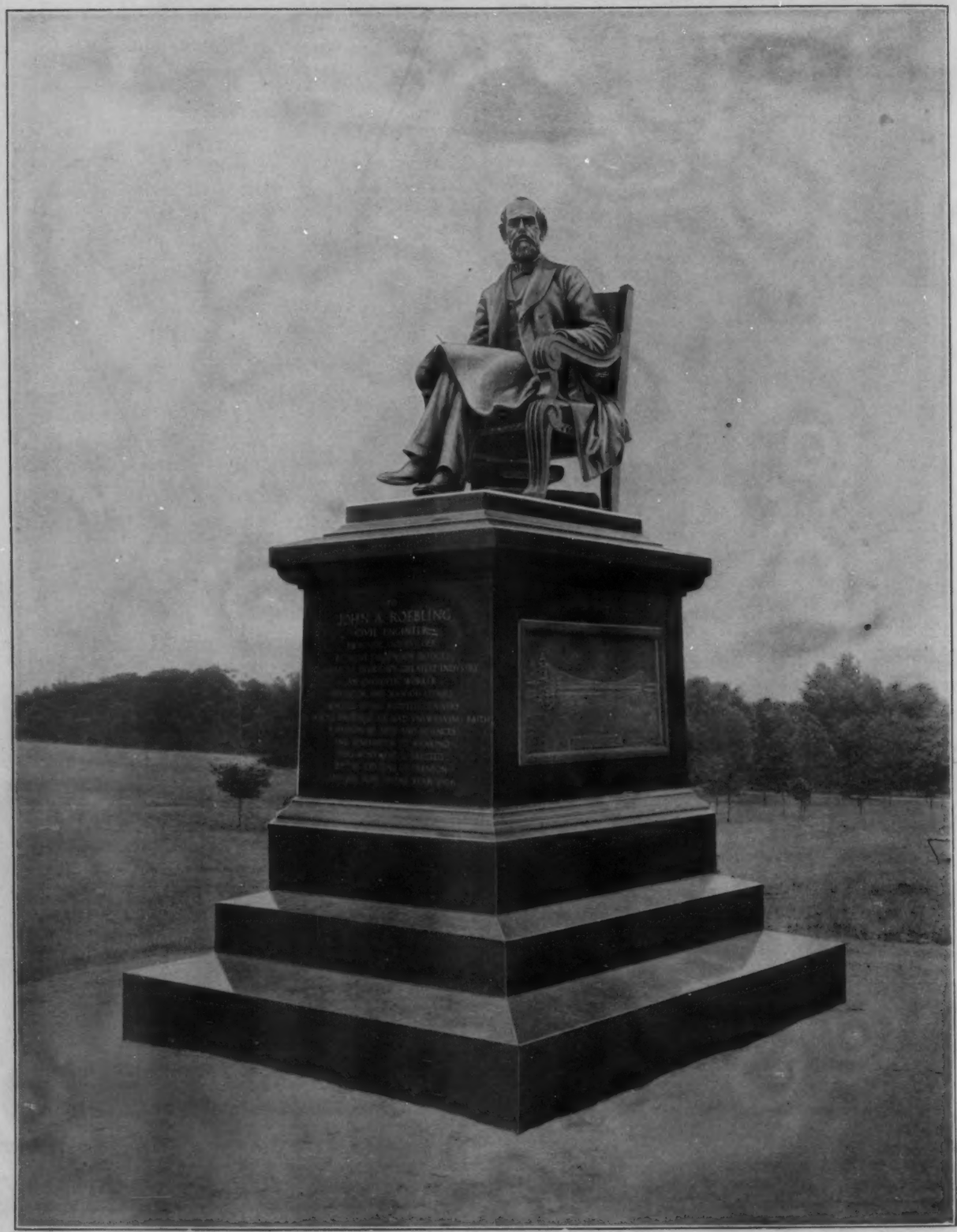

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THE

Journal of Electricity, Power and Gas

Devoted to the Conversion, Transmission and Distribution of Energy.

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THE REDUCTION OF IRON ORES BY ELECTRICITY.*

By C. F. ELWELL.

With electric furnaces one usually associates the production of graphite, carborundum, corundum and a great many other commodities. This paper will deal with the production of pig iron from the ore by electricity. I will endeavor to give a brief historical note, showing what has been done to date, a little of the theory connected with the design and construction of commercial furnaces, and some of the commercial results which have been obtained, including those from the plant in Shasta County, in the development of which I have taken part. A few years ago the electric furnace was a scientific curiosity; today it is, in some localities, a substitute for the blast furnace.

The first electric furnace constructed was that of Sir W. Siemens in 1878. In 1882 he melted twenty pounds of steel in it. It was simply an arc furnace, the heat from an arc struck between two electrodes being confined in a graphite crucible to melt the charge. In 1883 Faure patented the first resistance furnace, heat being generated by the passage of the current through solid conducting rods imbedded in the bottom of the furnace.

The electric furnace from this time on was gradually developed for the production of aluminum, calcium carbide and carborundum. The first attempt to smelt iron ores was by Captain Stassano, in Italy, in the year 1898, when he patented his process. In 1899 the demonstration that his process would work was carried out. The furnace is really an arc furnace, but it is not for the results which he obtained that great credit is due to Captain Stassano, but for the impetus which he gave electric smelting in general. Up to that time it was considered that electrical power was far too expensive to compete with coke in any locality. This idea was taken more from the retail price of power, which the public generally did not know was fifty to one hundred times what it cost to generate. He built two of these furnaces for the purposes of making demonstrations. One had a capacity of 2000 amperes at 170 volts, and the other a capacity of 1000 amperes at 80 volts. With the smaller his figure for electric energy per ton of iron produced was .341 kilowatt year. As conditions vary so in different localities, I make the comparisons of the various furnaces in terms of the electrical power in kilowatt year per ton of iron produced.

A Keller furnace is in operation at the works of Keller, Leleux & Co., Livet, France. In March, 1904, thirty tons of ore were smelted in the presence of the Canadian Commission sent over by the government to study the production of pig iron by electricity. The energy used per ton of pig was .397 kilowatt year in the first experiment, and .188 kilowatt year in the second. The electrical measurements were not checked and show a great discrepancy.

As a result of the Keller experiment the Canadian government voted $15,000 in the spring of 1906 for the carrying out of experiments on a commercial scale. The services of Dr. P. Heroult, of aluminum and electric steel furnace renown, were obtained, and he designed and built a furnace of 160 kilowatt capacity at Sault Ste. Marie, Ontario, Canada. These experiments have come to be known as the "Soo" experiments. The furnace was single phase with a single vertical electrode. The bottom was made out of carbon paste and served as one terminal. The suspended electrode was attached to a winch, by means of which it was raised and lowered as the current varied. The voltage being fixed, it was necessary to do this if constant power was desired. Nineteen runs were made, varying in length from 1 hour 40 minutes to 64 hours 30 minutes, with an average length of run of 27 hours 12 minutes. It will be seen from this that it was quite impossible to run the furnace for any length of time. The results varied from .299 kilowatt year per ton of pig to .176 kilowatt year, with an average of .216. These results were figured on a basis of no charge for warming up the crucible; i. e., they represent the energy for reducing the ore. The measurements of electrical energy were taken in, to my way of thinking, a very unsatisfactory manner. Then again, they used a very large amount of charcoal, the combustion of which supplied a large portion of the heat.

As a result of these experiments a 3000 horsepower furnace is being erected on ground facing the Welland Canal, Ontario, Canada. It is expected to produce thirty-five tons of pig iron per diem with cold charge and forty tons with pre-heated charge. It is to be a three-phase furnace supplied with forty volts at the furnace.

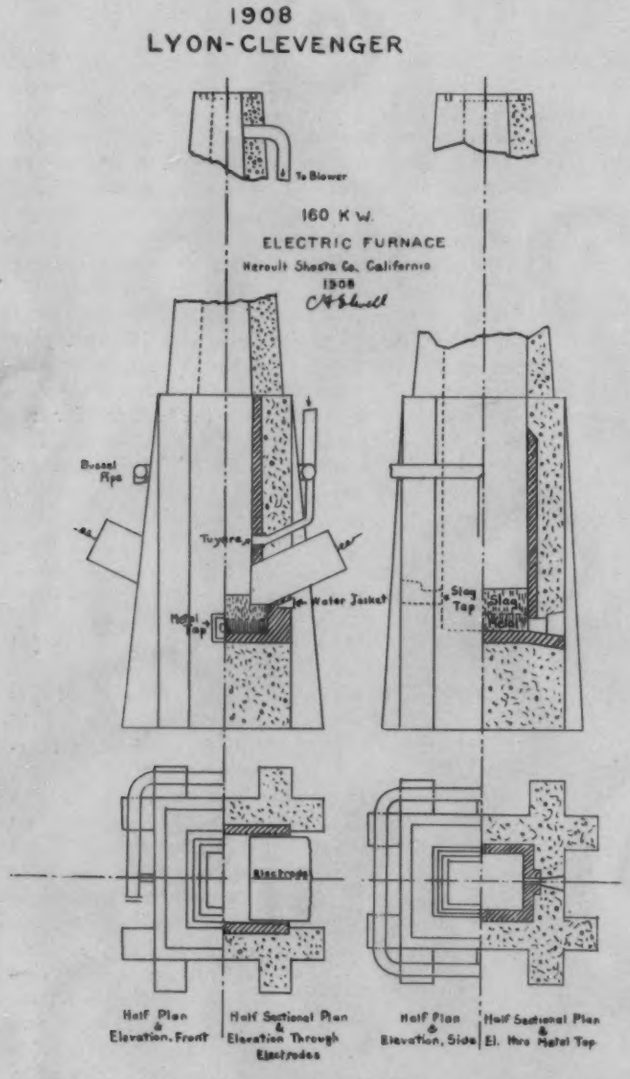
At the time of the Lewis and Clark Exposition at Portland, the United States government commissioned Dr. David T. Day to investigate the practicability of smelting the magnetic sands of this coast with the electric furnace. He used a furnace of the Heroult type, but he also used variable voltage. The variable voltage was found very useful, but no quantitative results were obtained. After Dr. Day returned to Washington, the work was carried on by G. H. Clevenger of Stanford University.

In July, 1907, H. H. Noble of the Northern California Power Company, loking for an avenue for some of the power developed by his company, engaged Dr. Heroult to design and build a furnace to smelt the iron ores of the Shasta Iron Company. A 1500-kilowatt, three-phase furnace was built and put into operation. It consisted essentially of a steel shell thirteen feet long and five feet six inches wide, lined with brick. Three electrodes were suspended above it on the same plan as the single-phase furnace built at the "Soo." The bottom was of carbon and formed the neutral point for a three-phase star connection of the furnace. It was confidently expected, on the basis of the results obtained at the "Soo," that it would produce twenty-four tons of iron per diem. As a matter of fact, I know of no run on which it made more than eleven tons per diem. Like the "Soo" furnace it was found impossible to run for any length of time. The electrodes being exposed to the great heat and to the oxidizing influence of the air, were consumed very rapidly. A new electrode having to be supplied every three or four days. It was next to impossible to get men to work with it because of its open construction, which made the surrounding atmosphere unbearable. The figure for energy was .26 kilowatt year per ton, which was very satisfactory, but the furnace would not produce enough iron at that figure to

*Paper read June 26, 1908, at meeting of San Francisco Section, American Institute of Electrical Engineers.

make it pay. One reason for this was the low-power factor, which was 73 per cent, and another was the inability to keep full power on the furnace all the time.

In January, 1908, a 160-kilowatt, single-phase furnace, after the designs of Prof. D. A. Lyon and G. H. Clevenger of Stanford University, was put into operation. The stack is of concrete and is twenty-nine feet high. The electrodes are fixed in the walls of the crucible and variable voltage is used to keep full power input on the furnace at all times. The charging is done from the top, and the long column of charge is effectually preheated before it reaches the zone of fusion, which is between the electrodes, which are placed



twenty-four inches apart. The crucible is lined with firebrick, well water cooled. The metal tap hole is a water-cooled casting, but the slag tap hole is not water cooled. The current is supplied by means of a 160-kilowatt, variable voltage transformer, supplying from sixteen to ninety-six volts in twenty steps. At starting, the highest voltage is used, and when running normally the voltage is about thirty-five-volts with corresponding current of 4000 amperes. To date six runs have been made, varying in length from 90 to 279 hours. The lowest figure for a run was .35 kilowatt year per ton of pig. This figure includes the preheating of the crucible before any charge is put into it. This preheating of the crucible takes current for about twenty-four hours before smelting is commenced. This charge will become insignificant in a furnace which will run for three or six months without being shut down, and this we hope to make the furnace do before long. Plans are now being drawn up for a 1500-kilowatt furnace along the same lines. It will, however, be a three-phase furnace.

I have endeavored so far to give only an historical resume of what has been done. In order that you may understand that these few plants and results represent a great advance in the art of smelting iron by electricity, I will now go into the design and construction of the electric resistance furnace in so far as used for smelting iron. The resistance furnace design when dealing with carborundum is a little different. I hope by this means to show some of the difficulties to be contended with.

An electric furnace consists essentially of three parts: A resister, in which the energy of the electric current is taken up with a view to obtaining a very high heat; an envelope to retain this heat, and electrodes to carry the current to the resister.

The Resister.

Heroult and Keller use the charge as a resister and melt it down by the Joulean effect of the current passing through it. They must first strike an arc in order to get some of the charge melted, as cold charge is a very poor conductor. In our experimental work we have used a bath of slag as a resister. Slag has the property of being a good conductor when liquid. When solid, it is a very good insulator. The introduction of iron ore, which has been partly reduced on its way down the stack, into this molten slag bath results in the speedy reduction of the spongy iron to the molten state. The slag bath is generally 200 C higher temperature than the melting point of iron. In designing the furnace, the size of the crucible depends on the amount of energy available. The rate of production of heat is measured by the number of watts per cubic inch, or kilowatts per cubic foot. The rate of heat production which is necessary to enable a certain temperature to be attained may be calculated from a consideration of area, thickness and conductivity of the walls of the furnace. The introduction of masses of comparatively cool charge must be taken into account. So little has been done that it is difficult to refer back to furnaces which have attained definite temperatures with definite consumption of electric power. An analysis of the kilowatt per cubic foot of the furnaces built and operated to date shows a fair uniformity and may be stated to be from seven to fifteen kilowatts per cubic foot of crucible, although it is difficult to agree on just what is the crucible.

The Envelope.

Taking up next the envelope, we come to the part of the electric furnace which is most troublesome. The conditions are not the same as in copper smelting furnaces or blast furnaces. In the copper smelting furnace the crucible is a solid water jacket. This construction cannot be used in the electric furnace for obvious reasons. Heavy brickwork, cooled by means of a heavy cast iron plate, cooled by means of a spray of water, as used in blast furnace work, is also impracticable for electrical reasons. The envelope consists in general of some holder, preferably of as good a heat insulator as possible, and a refractory lining. The subject of refractories is an important one in any furnace, but with the highly localized heat of the electric furnace, it is even more so. To give you an idea of the refractories at our disposal, I will mention the kind of brick and the temperature at which they melt.

Fireclay	1400-1800° C
Silica	1700-1800° C
Magnesia	2000° C
Bauxite	2000° C

The brick used as a refractory lining not only have to stand the great heat, but also the chemical attack of the hot slag. A basic brick must be used with a basic slag and an acid

brick with an acid slag. The brick must be efficiently cooled, for they will not stand any length of time without this protection. Care must be taken in the arrangement of the water jackets, or else electrical difficulties will be met with. The brick at high temperatures are very good conductors of electricity, especially magnesite.

The outer or heat insulating envelope has been usually of steel, water cooled, but this is bad because of the effect of the shell on the power factor. The power factor of the "Soo" furnace was claimed to be 91.9 per cent. The power factor of the Heroult furnace in Shasta County was only 73 per cent. In our experiments we used an outer shell of concrete and found it a splendid heat insulator, and having no bad effect on the power factor. The power factor of the single phase furnace was 95 per cent. A great deal depends on the layout of the busbars carrying such large currents, whether the power factor is good.

The Electrodes.

The electrodes are usually of amorphous carbon, though graphitic carbon is also used to some extent. The graphitic carbon electrodes are smaller for a given amount of current, because it has four times the conductivity of amorphous carbon. With the low current density necessary in order that the electrodes do not become the resisters instead of the charge, the electrodes become very large. The best electrodes come from Sweden, and are manufactured by the Heroult process. They are usually 16-inches by 16 inches and 6 feet long. Some electrodes are manufactured in Cleveland which are 18 inches by 18 inches, but have not given satisfaction to us. Dr. Heroult shows his faith in the future of electric smelting in the United States in the fact that he is putting up an electrode plant to manufacture his type of electrodes here. Electrodes are very easily oxidized when hot, and Dr. Heroult allows a sum of 36 cents per ton for electrode charge. Captain Stassano allows 70 cents to $1.00 per ton for the electrode consumption. According to our experience with the three phase furnace, the above figures are too low. The open construction readily admits air to the hot electrodes, and they are rapidly consumed. When making ferro-silicon with the three phase furnace, the electrode charge was about $14 per ton. The consumption with the Lyon single phase furnace is negligible. We have used the same electrodes for all of our experimental work. The contacts between the busbars and the electrodes have to be efficiently water cooled.

It is certain that for the reduction of iron from ore, the electric furnace can successfully compete with the blast furnace only in special localities, under conditions which are specially favorable to the electric process and unfavorable to the blast furnace. These conditions are essentially cheap electric power and scarcity of coal. If we assume an efficiency of 25 per cent for fuel heating and 75 per cent for electric heating, then electricity is cheaper than coal only when one ton of coal costs more than one half the cost of an electric horse-power year.

To give an idea of the comercial practicability of smelting iron ores by electricity, it will be well to give you some estimates based on actual operation.

Captain Stassano. Thirty tons in twenty-four hours.

48 tons of ore at $3.60	$173.00
6 tons of flux at $1.00	6.00
7.5 tons of coke at $9.40	70.00
Electrodes at 72 cents ton	21.60
Maintenance of furnace	72.00
Wages	36.00
Tools	18.00
Power at .341 kilowatt-year per ton and 1 kilowatt-year, $16.70	171.00
Mixing charge	50.60
Incidentals	18.00
	$636.30

Less combustible gases obtained and sold at 40 cents per 1000 cubic feet, gives an average of $17.63 per ton.

This estimate is supposed to apply to the north of Italy. The cost of the ore seems high, the labor low and the incidentals low. The probability of being able to sell 27,000 cubic feet of gas per diem is problematical.

Dr. P. Heroult. 10,000 horse-power plant, producing 120 tons per diem.

Ore at $1.50 per ton	$ 2.70
Charcoal, one-half ton at $6.00	3.00
Energy	2.43
Labor	1.00
Limestone	.20
Electrodes	.36
General expenses	1.00
	$10.69

This estimate was made before his attempt to make even twenty-four tons per diem. The energy is very low and the charcoal is about half what he used at Heroult, Shasta County.

What I consider a very conservative estimate, including local conditions, for a 1500 kilowatt furnace, producing fifteen tons per diem, is as follows:

22.5 tons of ore at $1.75	$ 39.60
1.5 tons of limestone at $1.00	1.50
1.5 tons of andesite at 1.00	1.50
6 tons of charcoal at $10.00	60.00
Electric energy at $5.00 per ton	75.00
3 furnace firemen at $3.00	9.00
3 men charging at $2.50	7.50
3 men, mixing charge at $2.50	7.50
1 electrician	3.00
	$204.60

Or $13.64 per ton. To which adding $2.50 for incidentals, makes a total cost of $16.14.

With a plant installed to obtain the by-products from the charcoal, the figure for charcoal may be greatly reduced. The electric energy, with the results actually obtained, would seem reasonable, being .31 kilowatt-year per ton.

The method of procedure in smelting ores by electricity may be of interest. At Heroult, we first fill the crucible up to the top of the electrodes with previously heated coke. A fairly low voltage is then applied, and the coke conducts enough current to keep it hot and gradually heat up the crucible. After about twelve hours, the first charge is fed in. This is a slag charge consisting of iron ore, to combine with the carbon which is in the furnace in the shape of coke, lime and andesite. After this has been put in at the rate of a shovelful every four minutes, the regular charge is commenced. This for example, consists of 1000 pounds of iron ore, 253 pounds of charcoal, 100 pounds of lime and 165 pounds of andesite. This is fed in fairly rapidly at first, so as to get a column of charge in the stack.

As soon as the slag charge gets down to the melting zone, which is just above and between the electrodes, it is melted. The charge is sufficient to fill the 24-inch by 36-inch crucible up to the desired height. The ascending gases reduce the ore on its way down the stack, and the spongy iron is melted when it encounters the slag bath, which is several hundred degrees higher in temperature than the melting point of iron. The molten iron collects in the bottom of the crucible and is kept hot by the passage of part of the current through it. After about four hours the furnace is tapped. This is done by means of steel chisel bars. The metal tap hole is water-cooled in order to protect the brickwork around it from the scouring action of the metal. Only a small amount of slag is tapped with the metal. Any surplus is taken out by means of the slag tap hole, which is at a height sufficient to keep the requisite slag bath in the furnace.

Changes in the composition and mixture of the charge make the resistance very variable. By using variable voltage on the furnace terminals, the power taken by the furnace may be kept comparatively constant at all times. At one time the voltage will be twenty-five volts. Then it will gradually rise until it is necessary to use as much as fifty volts to keep full power on the furnace. After tapping, the voltage has generally to be raised, and if the load is a large current at small voltage, it is a sure sign that the furnace needs tapping.

I have dealt almost exclusively with the electrical side of the smelting of iron ore in the furnace. The reason for this is that to go over the metallurgical side of the process would be to almost repeat what takes place in the blast furnace. The great difference lying in the exclusion of air, though it is found advantageous to burn a quantity of air on the top of the charge. There is nothing romantic about the use of electricity for smelting. It is only the substitution of a form of heat which in some localities is cheaper that that obtained from the combustion of coke or charcoal by means of an air blast. Less carbon is needed than in a blast furnace, where the combustion of carbon supplies the heat. In introducing a new piece of apparatus it is necessary to show some advantages which it has over another and old established piece of apparatus. Some of the good points in favor of the electric furnace are as follows:

(1) Original small cost of the furnace.
(2) Absence of bulky and costly charging machinery.
(3) Small expense involved through breakdown.
(4) Small cost and ease with which repairs may be made.
(5) Loss due to wrong composition of charge reduced to a minimum.
(6) Quality of iron is much better.
(7) High sulphur ores can be converted into low sulphur pig.
(8) No danger of the formation of cyanides, due to the presence of nitrogen.
(9) Silicon can be varied as required.

Ores containing as high as 1.5 per cent sulphur can be reduced in the electric furnace, while anything over .1 per cent is unusual in blast furnace practice. I carried out a small experiment on iron pyrites and obtained iron in which there was only .1 per cent sulphur.

The introduction of the electric furnace permits of the use of water powers, which cannot at present be profitably employed for any other purpose.

At the present time the governments of Brazil, Chili and India are inquiring into the practicability of the process, and it will not be many years before large electric furnace units will be employed in many parts of the world. We can take credit unto ourselves here in California that it was a Californian, Mr. H. H. Noble, and in California that the first successful smelting of iron ores in the United States was carried out.

CIVIL SERVICE EXAMINATION.

The United States Civil Service Commission announces an examination on August 12-13, 1908, to secure eligibles from which to make certification to fill a vacancy in the position of assistant, at $1,400 per annum, in the Naval Observatory, Navy Department, Washington, D. C., and vacancies requiring similar qualifications as they may occur.

The examination will consist of elementary mathematics, including algebra, geometry (plane and solid), trigonometry (plane and spherical), elementary analytical geometry, calculus and its applications to analytical geometry and mechanics, astronomy, general and practical, spherical astronomy and astronomical computations, training and experience in scientific work, including making and reducing astronomical observations (rated on application).

NOTES ON THE ELECTRIC HEATING PLANT OF THE BILTMORE ESTATE.*

By Charles E. Waddell.

Under the conditions of modern life electricity is an indispensable adjunct to the successful conduct of an establishment the size of Biltmore House; in this residence, besides the power, lighting and signal service, it is now also used for heating.

For the last two years both the hot water system and the laundry have been operated by electricity. Before entering upon a detailed description of the systems, the reasons for the substitution of electricity for fuel will be briefly stated. Under former conditions, to supply the laundry with steam and to maintain a supply of hot water, it was necessary to keep both a hot water heater and a high pressure boiler constantly fired. To operate the plant required the services of three attendants. At certain hours every day a portion of the attendants' time was required by other duties; but in the summer months and when the house was unoccupied, their entire time was virtually bestowed upon this very small duty. Anthracite coal, costing approximately $11 per long ton, was used. The difficulty in maintaining an adequate supply, together with the noise and dirt incidental to unloading, and the cost of the removal of the ashes, rendered its use undesirable and very expensive.

The majority of Southern hydroelectric corporations furnish power under certain imposed conditions as to peak, load-factor and the like, at approximately 8.5 miles per kilowatt-hour. A study of all the conditions and a review of these facts indicated that economy would result from an abandonment of fuel and the introduction of electric heat.

The plant as it stands has a capacity of 167 kilowatts and it has thus far fulfilled all expectations as to economy and reliability.

Hot Water System. The hot water system is that common to all large buildings. It consists of a loop system of piping, leading from storage tanks, and so laid out that gravity maintains a constant circulation. As a consequence, the temperature is to all practical purposes uniform throughout the house, and on no lines is it necessary to withdraw a quantity of cold water before the hot comes. The stand-by losses are of course excessive, but the comfort more than compensates for the additional cost. Two storage tanks are employed, each with a capacity of 500 gallons. Into the top of one of these cold water from the main enters; from the side and bottom a loop of three-inch pipe is taken out and carried to the heaters, which are located some twenty-five feet lower. The heaters are the lowest point of the system.

Heat was formerly supplied by a type of heater, which closely resembled a self-contained vertical tubular boiler. To maintain an adequate supply of water at a temperature of 200 degrees Fahr. required a fuel consumption of ten pounds of anthracite coal per hour. Tests of long duration showed this to vary but little.

The electric heater is a cylindrical steel tank, three feet in diameter by five long, containing twenty flues arranged in two concentric circles, and the whole closely resembling in appearance a miniature horizontal tubular boiler. Each of the twenty flues contains a heating element of five-kilowatt capacity; consequently the total capacity of the heater is one hundred kilowatts. The connecting terminals are brought out at one end of the tubes; at the other end a nut holds the elements in place. The withdrawal of the element is accomplished by simply removing the nut.

The electric heater is installed beside the coal heater and the two are provided with valves so that either or both may be used as occasion demands.

*A paper presented at the Twenty-fifth Annual Convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 1908.

Electricity is supplied in the form of a three-phase, sixty-cycle, alternating current at a potential of 230 volts. A switchboard panel is installed immediately in front of the heater and the elements are grouped thereon in three banks, each bank connected to phase, a feature of great value in balancing the load on the transformers. The power-factor of the element is unity. This was determined by observing the current consumption first on the direct-current circuit, and then on the alternating, the amperage in each case being the same.

The form of the hot water heater and the uniform rate of fuel consumption led to the conclusion that its efficiency was considerably higher than the ordinary steam boiler, and probably approximated 65 per cent. Assuming the coal to have a heat value of 14,000 British thermal units, the effective value would be 9100 British thermal units; and since one kilowatt hour is equivalent to 3412 British thermal units, it appeared that an input of 26.6 kilowatts would be an equivalent.

The approximation was so close that when the electric heater was placed in service, 30 kilowatts were applied; and with the exception of a few hours in the late evenings when five or ten kilowatts more are necessary, or the early mornings when not so many are needed, this input has been varied but little.

The energy input in any apparatus is divided into useful work and heat losses; in heating apparatus, since the entire work is the production of heat, where the elements are totally immersed, the efficiency theoretically should be 100 per cent. This is modified to some extent by the heat absorbed by the material of which the element is made.

In order to determine the actual working efficiency of the above heater, its piping was disconnected from the system, cold water was introduced, and the valve so adjusted that with a fixed input of forty kilowatts the water discharged was at constant temperature. The discharge was weighed, the input meter read at the start and conclusion of the test, and from these data the net efficiency found to be approximately 85 per cent. That is to say, 85 per cent of the input becomes available and effective in the hot water system; the other 15 per cent is lost in radiation from the boiler shell, through the tubes and from the attachments and piping. The author is of the opinion that the recorded efficiency is too low and may be considered as ultra conservative. Nevertheless, it represents the efficiency of the plant under everyday working conditions, and is not a test under artificial conditions, such as electric apparatus is often subjected to and which bear scant relation to working conditions.

The water at Biltmore contains a number of carbonates, causing boiler flues to form scale and incrustations rapidly and to an excessive degree; and with all steel piping which is subjected to a cycle of temperature change there is a continuous struggle to remove this coating. In the light of experience, although it would materially increase the cost, the use of copper flues instead of the iron ones now employed seems a justifiable expense. With a flue that would not retain scale, the formation of scale on the shell would be in the nature of additional heat insulation and would be beneficial rather than otherwise.

Ordinarily the deterioration of electric heating elements appears to be rapid; 10,000 hours is seemingly the maximum guarantee to be had. In the case of an element employed in heating water, where the element is at all times submerged, the maximum attainable temperature difference is but 180 degrees Fahrenheit, and the deterioration is nothing like so rapid as in other classes of service.

Speaking in the dual capacity of purchaser and seller of power, the writer does not hesitate to say that electric heating for hot water service is the most satisfactory and profitable load to be had. Peak loads are the rare exception; close regulation is non-essential, and momentary interruptions to service are of no importance; and even in prolonged shut-downs the slow thermal change of the liquid is such that ample time to start the auxiliary fuel plant is afforded.

The cost of the fuel heater, complete, installed, was about $350. The cost of the electric heater, complete, installed, and including switchboard, foundations, and pipe connections, was approximately $1200.

Laundry Equipment.

The electric equipment installed consists of: One dry room heater, capacity approximately 16 kilowatts; 1 mangle, 48 inches by 16 inches, capacity 8 kilowatts; 4 4-iron stoves, each with a capacity of 2 kilowatts, total 8 kilowatts; 1 steam generator, capacity 35 kilowatts. Total capacity, 67 kilowatts.

From the main switchboard current is conducted to the laundry by three 500,000 cir. mil. cables which terminate in a three-wire cabinet, the capacity of the panel being 1000 amperes. All conductors are run in galvanized conduit, the most substantial construction is followed, the aim being to secure an installation comparing favorably with steam apparatus in simplicity and durability. All laundry apparatus works interchangeably on direct or alternating current.

The dry room with a cubical contents of 640 feet is provided with three heating elements in the form of plates which are supported on porcelain insulators resting on the floor. Connections from the controlling switch box are made through asbestos covered wire, and mechanical, in preference to soldered, joints are used where possible. The dryer is equipped with the ordinary form of vertical clothes racks traveling on rollers. To accelerate the process of drying, an 18-inch galvanized iron flue leads from the top of the room to a nearby chimney. In laying out this apparatus it appeared feasible to supply only heat sufficient to maintain circulation, the theory being that rapid passage of warmed air would more or less mechanically exhaust the moisture.

In this connection it may be of interest to show how the equivalent heating capacity was determined. Originally the room was equipped with 108 square feet of radiation in the form of 1-inch pipe. The steam pressure was kept at 60-lb. gauge, representing a temperature of 309 degrees Fahrenheit. The temperature of the air in the dry room was usually 185 degrees Fahrenheit, a difference of 124 degrees Fahrenheit. Assuming that 1-inch wrought iron pipe radiates 2.9 British thermal units per square foot per degree difference of temperature, and since one kilowatt-hour is equivalent to 3412 British thermal units, we have:

$$\frac{2.9 \times 124 \times 108}{3412} = 11.4 \text{ kilowatts.}$$

Practically 12 kilowatts, a capacity on which all estimates were based. The discrepancy between the calculated and installed capacities is due to our use of certain elements on hand that would otherwise have been idle, and the greater capacity appears to facilitate the work.

The following is the average weekly performance, the dryer being used three days and each day listed separately for comparison:

Monday, March 30, 1908. General household wash, such as shirts, underclothes, stockings, table linen, towels, sheets, etc.

Number of hours used	10.5
Number of articles dried	339
Weight of articles dry, lb	103
Average temperature	101° fahr.
Number of lb. water expelled	84
Kilowatt-hours	124
Lb. water expelled per kilowatt-hour	0.68
Lb. clothes dried per kilowatt-hour	0.83
Number of pieces per kilowatt-hour	2.73

Thursday, April 2, 1908. Used for drying 18 shirts only. Shirts had been starched.

Number of hours used	4
Number of articles dried	18
Weight of articles dry, lb	9

Average temperature .....110° fahr.
Number of lb. water expelled..... 12
Kilowatt-hours..... 68.4

The heater was turned on at 8 a. m. and in empty state reached working temperature in one hour. Clothes were put in 1.5 hours after current was turned on; the mere act of drying, therefore, required 33 kilowatt-hours.

Friday, April 3, 1908. Second general wash.

Number of hours used..... 7.25
Number of articles dried.....276
Weight of articles dry, lb.....143
Average temperature .....110° fahr.
Number of lb. water expelled.....182
Kilowatt-hours 125
Lb. water expelled per kilowatt-hour.... 1.45
Lb. clothes dried per kilowatt-hour..... 1.14
Number of pieces per kilowatt-hour..... 2.20

Clothes ordinarily enter the dryer at a temperature of 83° Fahr., having previously been raised to a high temperature in the process of boiling and washing.

The steam mangle formerly used was converted to electric service by providing the rotating drum with heating elements.

Connection with the circuit is effected by means of a 3-ring collector and carbon brushes. Three degrees of heat may be had. The maximum input is eight kilowatts, and the heating intensity is 475 watts per square foot of surface. The performance of this machine is far more satisfactory than when used with steam; especially gratifying is the absence of leaky stuffing boxes.

The record of an average day's work is given below:

Current turned on mangle at 6:30 a. m.

Mangle started to work at 8:30 a. m., stopped at 2:30 p. m., off 45 minutes for lunch; off 30 minutes to cool; total hours current was on, 6:45.

Amperes, 45; volts, 118.

Two girls working. Articles mangled were towels, tablecloths, napkins, sheets, bedspreads, pillow cases.

Total weight articles in lb..... 221
Total square feet mangled 12,256
Total number of pieces..... 471
Total kilowatt-hours 35.8

All pieces were passed through twice, and many pieces three times; this accounts for the large surface area. The articles were cotton and linen.

The cost of equipping this mangle, including freight, drayage and installation, was approximately $175.

The diversity in weights, shapes and uses of the sad irons in this laundry led to the selection of electric stoves in preference to electric irons. Experience has taught that such claims were given undue consideration, and I am now of the opinion that an equipment of electric irons, weighing from seven to twelve pounds, would be preferable. For heating very special shaped irons, used on laces, etc., one stove might prove necessary. A consideration entirely apart from the merits of the irons has led to their partial abandonment, and that is that with the advent of the electric apparatus the temperature of the laundry was lowered to a degree where the ironed clothes would not "air" properly, and it was found necessary to keep the coal stove going to overcome this obstacle. It appears that where clothing is at once stored, and not again immediately used, that this "airing" is essential to their preservation. With the coal stove working the use of the electric stoves was in the nature of a waste.

Below is given the record of a day's ironing, using the electric stoves:

Two girls worked six hours each.

Two hundred and nineteen pieces ironed; articles were stockings, handkerchiefs, towels, napkins, pillow cases, petticoats, skirts.

Gross weight, damp, lb.....63
Net weight, dry, lb.....41
Kilowatt-hours 24

It required forty minutes to bring stoves and irons to working temperature. An iron heats in eight minutes after being returned to the stove and will hold sufficient heat to iron from four to seven minutes, depending on the dampness of the article and the material. To properly iron a handkerchief requires seven minutes; a bath towel, four minutes.

The foregoing data are submitted simply as an illustration of actual performance and represent average results; they are given in detail that others working along the same line or being confronted with new problems may glean some help from our experience. When the plant was begun we quickly realized the dearth of available data, and I believe that if all experimenters will publish the results of their investigations, facts will be gathered from the mass of testimony which will result in improved and more efficient apparatus.

Allusion has been made to the use of electric irons versus electric stoves. In connection with the former attention is called to the matter of cords and attachments. These are the weak points in this class of apparatus. The cords get damp and short-circuit, the terminals break loose, and the insulation frays off. For small irons and light service the existing practice is fairly good, but in heavy work, to insure success, a more substantial equipment must be designed.

By far the most interesting piece of electrical apparatus at Biltmore is the steam generator. With the abolition of steam service some method of boiling the clothes had to be provided. Of the several suggested and tried forms, the one in use seems best suited to the requirements. In the winter when steam heat is on the house, it is in the direction of economy to use steam from the mains. For nine months of the year heat must be secured elsewhere. Boiling the clothes is an essential process. To retain intact the steam apparatus was an obvious desideratum; to provide supplementary electric apparatus introduced complications; and a compromise was effected by generating steam with electricity, piping the generator into the steam mains, a series of valves rendering the two sources of heat interchangeable. The steam generator consists of a group of five three-inch vertical pipes. Around the pipes the heating elements are placed. The pipes are interconnected at both top and bottom; the top is pro vided with a steam dome, and the whole is equipped with water column, steam gauge, pop valve and inlet water regulator. The function of the regulator is to keep the water level in the boiler constant. Feed water is taken from the hot water mains. At the base, and integral with the frame, are five switches, each controlling a 7-kilowatt element.

Steam at practically zero pressure is conducted to five tubs and there discharged through perforated pipes located in the bottoms. The tubs are made of porcelain and contain about two cubic feet each.

When new the generator was tested to determine its evaporative efficiency. This was found to be between 95 and 100 per cent. The appliances at hand were not adapted to precise work, but the result is not very far wrong in my opinion. The test was made by bringing the contents of the boiler to the boiling point, marking the height of the water on the gauge glass, evaporating a given weight and ceasing when the water in the boiler was level with the starting point. The meters were read at start and finish, and the input determined. The varying barometer and the inaccuracies of the thermometers introduced error, and it is by no means certain that the meters were exactly right, although they were new and of the highest grade.

In service the performance is as follows:

Ninety-two pounds water in tub.

Seven pounds linen in tub.

To raise to boiling point requires 10 kilowatt-hours.

Clothes are boiled 20 minutes, and current consumed is 4 kilowatt-hours.

Total kilowatt-hours per batch, 14.

Digressing from the subject, it seems to the author that this form of steam generator is admirably adapted to the service of train heating, where steam and electric locomotives are

alternately employed. Worked in connection with a return system of piping, water storage only sufficient to supply leakage would be necessary. The generator being located on the locomotive, the increase in weight on the drivers would be an advantage. The low cost and the simplicity of the apparatus, together with the fact that it would fit existing equipment, should, I think, render an experiment worth while.

Plate Warmer.

In addition to the two large classes of service that have been described, there is installed in the butler's pantry an electric plate warmer. This piece of apparatus is in the form of two shelves, each 24.5 inches by 43 inches, and each with a rated consumption of 840 watts, an equivalent heating effect of 0.8 watts per square inch of surface. Each shelf is provided with its own switch. The ordinary double-pole indicating snap switch is employed for control, the wiring is of the fireproof form of insulation, and the current supply is taken from a nearby lighting main. The lighting system being designed for operation on either the alternating bus-bars or the direct-current storage battery bus-bars, it follows that, like the laundry, the plate warmer works interchangeably on the two classes of service.

At the time of purchase this type of heating apparatus sold for approximately $6 per square foot.

Conclusion.

As was aptly pointed out in an editorial of a representative technical paper not long since, electric heating has suffered from the fact that its economic possibilities have usually been considered from its thermal unit value; and the lesson to be drawn from the Biltmore installation is that a careful analysis of all the conditions may disclose the fact that while theoretically a disparity exists, nevertheless economy may accrue due to the better operating conditions.

Enthusiastic advocates of electric heating are today making broad claims, which in a measure mislead the uninitiated. This, in the author's humble opinion, should be discouraged. The prices at which electric power is generally sold and the state of the heating art do not as yet admit a wholesale and unreserved usurpation of the heating field, and it is a question whether this state ever will be reached. One thing, however, is certain, and that is that Utopian dreams and unsubstantiated claims are going to do much harm and no good, and all projected heating installations of any magnitude should be accorded careful attention and considered in the light of an engineering undertaking, not merely as a matter of domestic or commercial installation.

We have found that the standard forms of enclosed fuses when continuously worked at or near their rated capacity on heating apparatus rapidly deteriorate, failing without apparent cause. For this fact I have no explanation to offer.

Experience leads to the conclusion that for heavy heating work a number of auxiliary appliances accepted as standards in lighting work will have to be either remodeled or abandoned. The temperature at which heating elements work renders the use of solder undesirable; in a number of instances that have come under our observation the terminals have melted off. The use of fireproof or asbestos covered wire is to be preferred to rubber, even in conduit installations.

Where cords are required it would appear better construction to use flexible armored cable. For stationary apparatus the switching devices should as far as possible form an integral part of the apparatus; and where necessary to separate the two, connection between them should be made through conduit, and both switch and heating element be arranged to mechanically unite with the conduit. In the majority of places where electric heating apparatus is employed water or steam is present, and for this reason the switching devices should be accorded special attention. The open knife switch is altogether unsuitable; the enclosed knife switch some, but not much, better; and the oil switch entirely out of place. A little mechanical ingenuity bestowed upon these details would effect a decided advance in the art and would eliminate one source of trouble.

WATER POWER DEVELOPMENT IN THE NATIONAL FORESTS.

By John A. Britton.

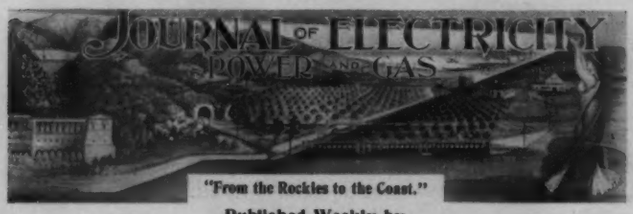
First, I believe that the United States should grant to all bona fide hydro-electric corporations permanent rights-of-way and grants of government land without any tax whatever being made therefor, other than the cost of the land, fixed by the government on the same basis as valuation is fixed for homesteaders. Such rights, when granted, to become permanent only upon the expenditure of a sum of money representing four or five times the value of the land, and to provide therefor that upon cessation of use for a period of one year, except in case of unavoidable accident or destruction by elements of the improvements, the grant should revert to the United States.

The protection of a watershed should be a matter within the province of the United States, without imposing any tax upon the users of the land. The resultant benefits gained by the United States and the several States in which these patents would be used, and the taxes derived therefrom, being, in my opinion, sufficient to warrant the government in taking care of and protecting watersheds utilized, as such care and protection results as much to the benefit of the entire community through which the streams may flow, as it does to the company utilizing the water for power purposes. I am unalterably opposed to the levying of any tax by the State, or by the United States, where forest reserves are concerned, against enterprises of this character. To subject an investment of this kind to the whims of the legislature of any State and the Congress of the United States would be to invite confiscation of property and would result in eventually paternalizing, and would, if neither of the above occurred, bankrupt any corporation, as it has no redress, nor can it in this State now, nor will it hereafter, be permitted to increase its rates, due to the trend of the present legislation in the matter of such close regulation of corporations. If any law is to be made, it should be a discriminatory one, choosing between the bona fide enterprises and those which are organized purely for the purposes of enriching the organizers.

I shall be very glad, indeed, to see a State or Coast convention held to discuss this subject. I believe it very vital to the welfare of those who have, in good faith, invested their money in water power propositions in this and other States.

WESTINGHOUSE REORGANIZATION.

The Merchandise Creditors Committee of the Westinghouse Electric and Manufacturing Company reports that ninety-five per centum in amount of all the Merchandise Creditors have assented to the Merchandise Creditors' Plan, and that they confidently expect to secure the assent of the major part if not all of the remaining merchandise claims. Substantial progress has been made toward securing from stockholders, employees and others the $6,000,000 of cash subscriptions to "assenting stock" required by the plan; and additional subscriptions for a considerable sum are assured, conditioned upon subscribers being able to make satisfactory financial arrangements therefor. It is, however, still necessary to secure the remaining cash subscriptions as well as the assents from the remaining Merchandise Creditors. Of the employees of the company, approximately five thousand have made subscriptions aggregating about $600,000. This action on the part of the employees should be an incentive to creditors and stockholders of the company to furnish as promptly as possible the remaining subscriptions required for the complete success of the plan. In consideration of the extraordinary effort which has been made by all parties interested, and the favorable results accomplished to date, the Readjustment Committee has agreed to a further extension, to September 1st, within which to finally complete the matter.



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EDITORIAL.

ELECTRIC SMELTING OF IRON.

The great region from the Rocky Mountains to the Pacific Coast has long paid a heavy freight tax for the iron it uses because it does not yield a suitable coking coal. Lying undeveloped within its confines are vast reserves of this dull gray metal with which the engineer has reared the edifice of modern civilization. But though the material with which to separate iron from oxygen may be scant, the power is abundant. By converting water into heat through the agency of electricity, there is available a powerful means for iron reduction. To attain this result, many costly experiments have been undertaken, and it is with pleasure that we record the results of the latest of these. Mr. C. F. Elwell writes elsewhere on the subject, giving much information of practical value. The experiments show and the figures prove that iron can be profitably won by means of the electric current.

This furnace is the successor of the 1,500-kilowatt Heroult furnace, erected on the Pitt River by Mr. H. H. Noble to smelt the ores of the Shasta Iron Company. While it demonstrated that pig iron could be produced commercially with three-phase current, its mechanical weaknesses made continuous operation impracticable. So Professor D. A. Lyon, Mr. G. H. Clevenger, and Mr. C. F. Elwell, all of Stanford University, were engaged to overcome these difficulties. They designed a 160-kilowatt, single-phase furnace operating with a voltage varying from 16 to 96 volts and taking about 4,000 amperes. In the course of six runs, one of which was of over ten days' duration, the best results obtained was .35 kilowatt year per ton of pig iron produced. Plans are now being drawn for a 1,500-kilowatt resistance furnace, built on similar lines.

Apart from the actual details of operation, the most interesting part of the paper is the estimate of the cost of producing pig iron. Experiments with the smaller furnace indicate that it will require .31 kilowatt year per ton of iron produced. The power costs $12 per horsepower year or $16 per kilowatt year, which gives $5.00 as the cost of the electric current to produce one ton of metal. Assuming the ore to cost $1.75 and coke $10 per ton, the total cost is estimated as about $16, which seems conservative. The electric furnace requires about one-third as much coke as a blast furnace.

If pig iron can be placed in Pacific Coast centers at a cost of $18 per ton, it will give a great impetus to the industrial development of the West. At Pittsburg the best pig iron is now worth from $16 to $17 per ton. In San Francisco the same grade sells at $26 to $28, owing to the high freight rate.

Heat from electricity cannot compete with heat from fuel without some handicap. If this be great enough, it offers the needed inducement to enter this novice against the veteran in the field of heating. For it is to be remembered that electric heating is yet a child, and judging from its past performances promises well for its maturity.

PERSONAL.

A. M. Hunt, of San Francisco, is in the East on a short trip.

H. B. Squires, of Otis & Squires, returned to San Francisco last week after a successful trip East.

Geo. R. Murphy, of the Electric Storage Battery Co., has returned to San Francisco from a short trip to Spokane, Wash.

H. R. Noack, vice-president of Pierson, Roeding & Company, of San Francisco, is taking a month's relaxation in the Sierra Nevada Mountains.

TRADE CATALOGUES.

Frank Mossberg Co., Attleboro, Mass., sent a leaflet on "The Imp", a gasoline torch for soldering and heating, for th use of electricians and telephone linemen.

Malleable and grey iron sundries for electric light, street railway, telegraph and telephone construction are listed in a pocket size catalogue from the Fletcher Manufacturing Co., of Dayton, Ohio.

The Cutter Company, of Philadelphia, send a pamphlet announcing a $1,200 prize competition for writers of the best essays on the use of direct-current or alternating-current, I. T. E. air brake switches. It will be sent on request.

Westinghouse Direct Current Electric Fans are attractively described in a handsome folder, No. 4101, from the Westinghouse Electric & Mfg. Co., of Pittsburg. No. 4100 is devoted to Westinghouse Fan Motors for Alternating Current Circuits. The covers of these pamphlets are artistic fancy pictures.

The General Electric Co., Schenectady, N. Y., has issued a comprehensive bulletin (No. 4593), devoted to the subject of "Railway Converter Sub-Stations." The publication gives a general description of the various pieces of sub-station apparatus, including rotary converter transformers, reactances, blowers, cables, switchboards, etc., and includes illustrations of converter stations operated by various well-known railway companies. It contains also plans and elevations showing different arrangements of sub-station apparatus.

REHABILITATION OF CAZADERO POWER PLANT.

The Portland Railway, Light and Power Company is making rapid progress in rehabilitating its wrecked Cazadero power plant. The water-wheels were not injured, and one has been direct-connected to a 2,000-kilowatt frequency changer. Another will be connected to a 2,500-kilowatt generator within two weeks.

TRADE NOTICES.

The Electric Controller & Supply Co., of Cleveland, Ohio, has changed its name to the Electric Controller and Manufacturing Co.

The Pacific Coast Department of the Holophane Company, F. H. Poss, manager, have installed 400 new crimped bowl Holophane reflectors in Taft & Pennoyer's new store in Oakland, through E. W. Jcakson, the successful bidder.

Geo A. Scoville, San Francisco resident engineer of the Dean Electric Company, states that the first consignment of stock has been received. This makes a "Dean" stock on the Pacific Coast a reality, and they are now prepared to fill orders at this point for standard telephones—telephone and switchboard parts. The company is giving a neat little souvenir, a watchmaker's screw-driver, to the trade, on request.

A MONUMENT TO JOHN A. ROEBLING.

On June 30th at Trenton, New Jersey, was dedicated a statue erected to the memory of the late John A. Roebling. Over 15,000 people assembled to witness the unveiling of this bronze monument to one of our greatest civil engineers, the occasion having been made a public holiday in Trenton and Roebling, New Jersey. Preceding the dedication was a procession of 6000 workers at the Roebling mills. Miss Emily M. Roebling, daughter of Chas. G. Roebling and granddaughter of John A. Roebling, unveiled the statue, and Henry D. Estabrook, general counsel of the Western Union Telegraph Company, father-in-law of Carl G. Roebling, gave the dedicatory oration.

Coming to the United States from Germany as a young man in 1831, John A. Roebling's engineering knowledge was first applied to canal work. He replaced the clumsy hempen rope by a flexible wire rope made by himself. This led to its application to small suspension bridges and culminated in the construction of the bridge at Niagara Falls and the Brooklyn Bridge. This great work was built after his own design and completed by his son. "All the latent poetry of the mathematician—and in its highest reaches mathematics becomes divinest poetry,—all the asceticism of the architect, all the musician's sensitiveness to harmony, all the mysticism of idealistic philosophy, whatever of faith, feeling and reverence John A. Roebling had in his heart, was here voiced like a ringing cry.

"As if conscious of his pending doom, his genius stands embodied in these finished forms—an inspiration visible—a soul's bid for immortality."

Another monument to the Roebling mills and name is the cable across the Straits of Carquinez in California, which is the longest uninterrupted span in the world, 4427 feet. The cables are of ⅞-inch Roebling galvanized steel strands, and have a breaking strength of 200,000 pounds to the square inch. They transmit electric current from the California Gas and Electric Corporation's hydro-electric plants in the Sierra Nevada Mountains.

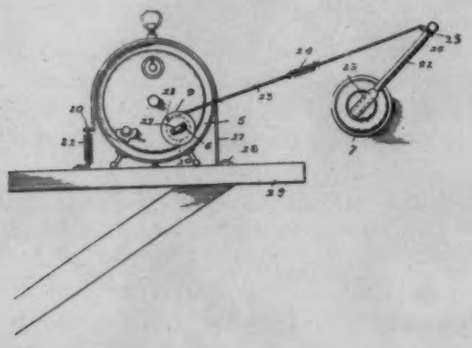
As a necessary corollary of this engineering work is the organization of the great Roebling factory at Trenton, N. J., where every process has either been invented or improved by the Roeblings. These works cover thirty-five acres and require 10,000 horsepower for their running and employ 6000 men. This great work, initiated by the father, has been ably carried to success by F. W. Roebling, Charles G. Roebling and Washington A. Roebling of the second generation, and F. W. Roebling, Jr., and Carl G. Roebling of the third.

The monument to Mr. Roebling is of bronze and measures six feet seven inches, the figure being modeled in a sitting position. The pedestal is built of red Swedish granite and stands fifteen feet seven inches high, exclusive of the concrete base. On the right side of this granite pedestal is a bronze panel containing a reproduction in relief of the first railroad suspension bridge built over the Niagara; on the left side is a similar replica of the Brooklyn Bridge; the inscription appears on the front. The monument in its entirety cost about $14,000. It is a visible expression of his townspeople's regard, although his work will live after him as an even more enduring monument, for few men have made a greater impression on an industry or have exerted a more beneficial influence on a community than John A. Roebling.

PATENTS

ELECTRIC-LIGHT CUT-OFF. 892,095. James B. Smith and Yancy D. Lott, Jackson, Miss.

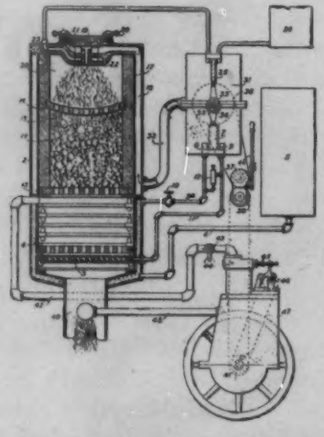
The combination with the button of a snap switch and with the winding key of an alarm clock, of an arm having an integral plate portion provided with prongs, the plate portion and the prongs being adapted to be bent to embrace the



button of the snap switch, a grooved disk provided with a slot in which the winding key of the alarm clock is received, whereby the disk will be held for rotation with the key when the alarm is struck, a cord secured to the disk in the groove therein, a similar cord secured to the outer end of the arm, and a spring connecting the ends of the two cords.

VAPOR-GENERATING APPARATUS. 892,097. Elihu Thomson, Swampscott, Mass., assignor to General Electric Company.

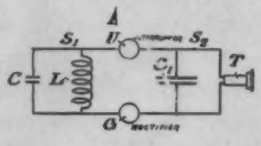
The combination with a steam generator wherein the heating power is supplied by a liquid fuel burner, of a pump and connections for supplying fuel to the burner, a pump and



connections for supplying water to the generator, means for uniting the pump pistons, means for driving the pumps, and means intermediate the driving means and the pumps for simultaneously changing the speed of the pumps without changing the speed of the driving means in a manner to cause corresponding variations in the supply of fuel and water furnished to the burner and to the generator.

SYSTEM FOR RECEIVING UNDAMPED ELECTRIC OSCILLATIONS. 892,312. Otto Scheller, Steglitz, near Berlin, Germany.

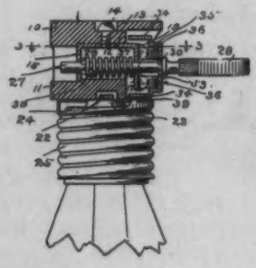
In a system for receiving substantially undamped oscillations, the combination with a high frequency circuit, and a circuit of lower frequency, of an interrupter connecting cir-



cuits and adapted to transmit current impulses of determined directions from the high frequency circuit to the circuit of lower frequency and working synchronously with the fundamental oscillation of the circuit of lower frequency, and an electrolytic cell allowing energy to be transmitted in one direction only.

ELECTRIC SOCKET-SWITCH. 892,375. Harvey Hubbell, Bridgeport, Conn., assignor to Harvey Hubbell, Incorporated, Bridgeport, Conn.

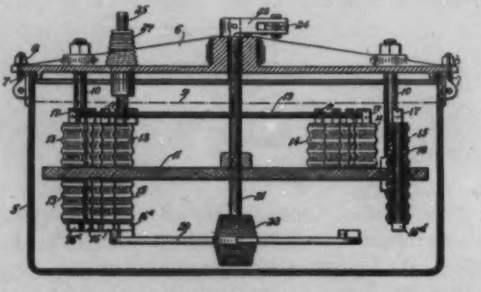
A socket switch comprising a contact bar and a contact plate, one of parts being provided with alternate projections



and depressions, and the other part engaging projections and depressions, a shaft loosely engaging the contact bar for the purpose set forth, and means for holding the contact bar and contact plate in engagement.

OIL-SWITCH. 891,833. Edward M. Gerry, Norwood, Ohio, assignor to The Bullock Electric Manufacturing Company.

In an oil switch or circuit-breaker, a tank containing oil, a supporting plate mounted within tank, insulating supports mounted on plate, contact segments mounted upon supports



on one side of plate, a bridging member adapted to engage contact segments successively, resistance sections mounted upon supports on the other side of plate and electrically connected to contact segments, and means projecting from tank for operating bridging member to include resistance sections in circuit as the switch or circuit-breaker is opened.

INDUSTRIAL

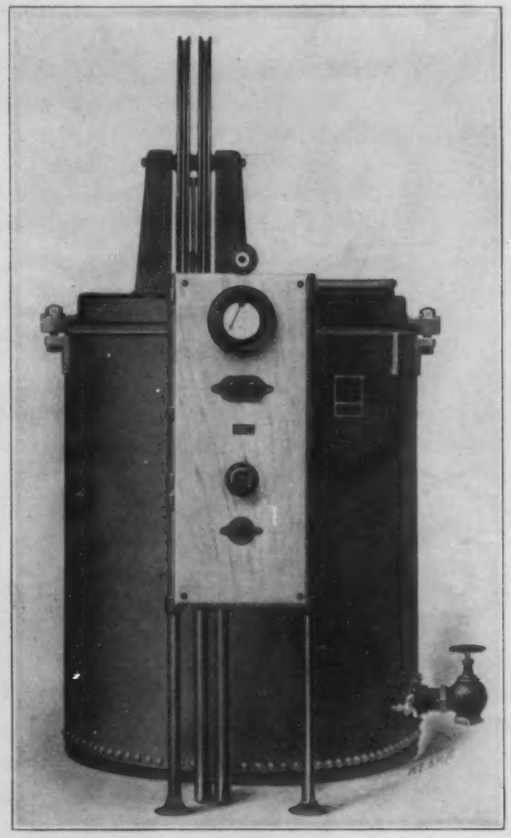
MERCURY RECTIFIER ARC LIGHTING SYSTEM.

The superior efficiency and light distribution of direct current series arc lamps make them highly desirable for outdoor lighting service. The only serious objection to their more general use has been the question of power distribution. These lamps require the use of constant current arc generators, and these machines are not as satisfactory nor as efficient as the constant current regulating transformers used with alternating current arc lamps. For this reason, the economy and other superior qualities of the direct current series arc lamp are frequently surrendered in order to take advantage of the more practical and efficient method of distribution offered by the alternating current system.

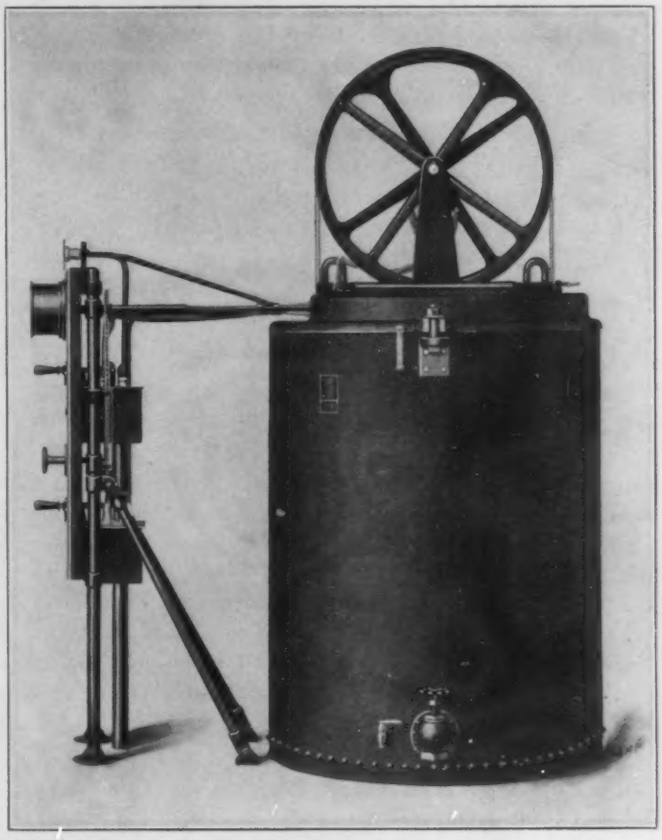
In order to secure the advantages of direct current series arc lamps and the alternating current system of distribution and regulation, the Westinghouse Company has recently introduced a new system of arc lighting, in which the most desirable points of both systems are combined. The alternating current supply is changed to a direct current by means of a Cooper-Hewitt mercury rectifier, and this rectified current is then available for operating direct current series arc lamps.

In alternating current stations which are furnishing outdoor arc lighting from series arc generators, a large saving in generating machinery, cost of operation and attendance may be effected by substituting rectifier outfits for the arc generators, and using the same lamps. The rectifier outfits operate noiselessly and efficiently, provide excellent regulation, and avoid the use of high-speed machines, with their belts, prime movers, shafting and other accessories, all of which require constant attendance and repairs.

The rectifier outfit consists of a constant current regulating transformer, a mercury rectifier bulb, and a panel containing the necessary switches, instruments, etc. The regulating transformer and the rectifier bulb are mounted in the same tank, and by means of such outfits power may be drawn from an alternating current circuit of either twenty-five or sixty cycles and delivered as direct current to the series arc lamp circuits. The rectifier bulb requires no manipulation except to start it, after which it operates without further attention. The outfit has no mechanical connection with any machinery requiring belted connections, there is no armature to burn out, commutator to renew, nor brushes to adjust. Its efficiency of transformation is very high, its depreciation is smaller than that of any other class of machinery, and the cost of maintenance and repairs is merely nominal. The renewal of the rectifier bulb at intervals is the only attention it will ordinarily require, and the outfit is so designed that a new bulb may be substituted for an old one without disturbing the rest of the apparatus or any of the connections. Its life under ordinary conditions of service will be guaranteed to average 500 hours, although this figure has been greatly exceeded.



FRONT VIEW OF 75-LIGHT MERCURY RECTIFIER CONSTANT CURRENT REGULATING TRANSFORMER OUTFIT.



SIDE VIEW OF 75-LIGHT MERCURY RECTIFIER CONSTANT CURRENT REGULATING TRANSFORMER WITH RECTIFIER PANEL.

NEWS NOTES

FINANCIAL.

San Francisco.—Springfield Oil Company has levied an assessment of two cents per share, delinquent August 3d, sale day August 22d.

San Francisco.—The Tavern Oil Company has levied an assessment of ten cents per share, delinquent July 30th, sale day August 19th.

San Francisco.—The Lorene Oil Company has levied an assessment of three cents per share, delinquent July 30th, sale day August 19th.

San Jose, Cal.—Mr. and Mrs. M. P. O'Conner of San Jose have presented Santa Clara College with $5000 for the construction of a water system for the new college buildings.

Yuba City, Cal.—In the election held June 30th for the purpose of voting bonds in the sum of $30,000 for providing the city with municipal waterworks, the proposition was carried.

Ocean Park, Cal.—The City Council has passed a resolution calling a special election to decide upon the matter of a bond issue for the purpose of extending the sewer system, improving the septic tank and extending water mains.

Los Angeles, Cal.—A deal involving probably $1,500,000 was completed July 9th when Henry E. Huntington, W. G. Kerckhoff and A. C. Balch of the Pacific Light & Power Company purchased the entire system of the City Gas Company, the chief competitor of the Los Angeles Gas & Electric Company. The buyers will organize a new corporation to operate this system, one agreement being that it will not sell out to the old company. It is believed, however, that the ultimate act of Huntington and his associates is to acquire control of the old company. For several months the old and the new companies have been engaged in fierce competition for mastery of part of the local field.

San Francisco.—The San Francisco Gas and Electric Company has been granted a temporary restraining order by Judge Van Fleet in the United States Circuit Court until September 8th, to prevent the Board of Supervisors enforcing the ordinance providing for an 85-cent gas rate. Until the hearing comes up in September, Attorney McEnerney promised the Court that the gas company would not enforce a rate higher than $1 a thousand. Assistant City Attorney Haven protested that if it developed that the company was only entitled to 85 cents a thousand the people would have to start individual suits for rebates and would forfeit the money rather than go to the expense.

Los Angeles, Cal.—Mendocino County is claiming recognition as an oil district. Seepages have been discovered near Point Arena and a company of Fresno men has been formed to test the district. The organization is headed by E. E. Bush, mayor of Fresno.

TRANSMISSION.

Red Bluff, Cal.—Dr. Carter of Tehama has filed on 10,000 inches of water in Mill Creek. The water is to be used to propel machinery and for generating electrical power.

Red Bluff, Cal.—Alfred T. Forward has filed on 3000 inches of water in South Digger Creek. The water is to be used for the purpose of generating electricity and to run a sawmill.

Redlands, Cal.—Another power house in Mill Creek Canyon for the purpose of utilizing the water which flows over the falls above Forest Home is to be built by a syndicate of Redlands men headed by J. S. Edwards.

Oakland, Cal.—The Tuolumne Water Power Company has filed suits to condemn a right of way for a high-tension power line across property owned by Thomas Anderson and Julia O'Leary in the southern portion of Alameda County. The power cables will be carried on steel towers, several of which are sought to be located upon the defendant's lands.

Reno, Nev.—Electricity generated by water from the Truckee-Carson irrigation project is being used to light Fallon, the seat of Churchill County. The water right is held jointly by the government and a local corporation, $75,000 being paid for it. A few days' test of the generators has proven that enough water is available to furnish power for industrial projects, and eventually it is planned to string wires into Fairview and Wonder.

Los Angeles, Cal.—The Los Angeles-Pacific Railway Company has signed a contract with the Marine Power & Electric Company, by which the new resort at Port Los Angeles gains a novel attraction. It is a wave motor. If it is successful, its first practical work will be the illumination of the long wharf and its next the furnishing of electric current for the Los Angeles-Pacific cars. The building of the plant is to begin at once.

Oakland, Cal.—The Great Western Power Company will at once begin the erection of a concrete substation building at White and Mathews Streets, Oakland. The building is to be three stories in height and a permit has been issued by the Board of Public Works. The cost is given as $44,800. The application for the permit was signed by William J. Miller, Crocker Building, San Francisco. Viele, Blackwell & Buck of San Francisco are the architects. A contract has been let to the Globe Construction Company.

San Diego, Cal.—The Home Telephone Company of San Diego has been taken over by a syndicate of Eastern capitalists. The names given are H. A. Harris and A. E. Wilson of Chicago, F. F. Graves of Ohio and C. P. Platt, the Pacific Coast representative of the Harris people. Mr. Harris, it is understood, represents the makers of the automatic telephone and telegraph exchange, as used by the local company. The price is said to be $120,000 and the assumption of all debts of the company.

TRANSPORTATION.

Redondo, Cal. — The Los Angeles-Redondo Railroad is planning to widen its track to a standard gauge.

Los Angeles, Cal.—The people of Downey are putting forth efforts to have street car connection with Los Angeles and surrounding towns.

Pasadena, Cal.—The City Council has advertised for sale a franchise asked for by General Manager McMillan of the Pacific Electric Company.

Santa Monica, Cal.—The City Council will at once advertise for sale of an electric street railway franchise as requested by the Los Angeles Pacific.

Alameda, Cal.—The Southern Pacific Company has notified the Mayor that it is ready to begin the work of electricizing its local railways in this city immediately.

Riverside, Cal.—Application has been made to the City Council for an electric railroad franchise, and the City Council offers the same for sale to the highest bidder on August 11th.

Los Angeles, Cal.—John D. Spreckels is running a survey for a new electric line, designed to reach his new irrigation project at the head of Cottonwood Creek, which will pass through Dulzura.

El Paso, Tex.—At a recent meeting of El Paso and Las Cruces business men, the feasibility of an interurban line between El Paso and Las Cruces was discussed, promoters having in mind the construction of such a line.

Santa Rosa, Cal.—It is announced that an electric railroad will probably be constructed between Ukiah and Potter Valley and may be extended into Lake County, tapping some of the best agricultural and timber country in that section.

Los Angeles, Cal.—Direct electric car communication between San Pedro, Wilmington and Long Beach is to be had at once via the Pacific Electric. Mr. Huntington says that he expects work to be started as soon as preliminaries can be concluded.

Yuba City, Cal.—The Northern Electric Co. will shortly complete the laying of track for the local street car system. The work was partly put under way several months ago, but when the stringency came in the money market, all work was suspended.

Ventura, Cal.—The Board of Trustees of San Buenaventura County have passed an ordinance offering for sale on August 10th a franchise to construct an electric railway, commencing at the south line of West Main Street, as applied for by F. M. Packard and E. W. Pratt.

Santa Barbara, Cal.—At a meeting of the supervisors the franchise granted to the Merchants' Mutual Light & Power Company, in September, 1906, to build and operate an electric line to Goleta was revoked and the way left open to any other company to secure the right to build the line.

Pasadena, Cal.—An extension of the Pacific Electric car line from Fair Oaks Avenue to West Montana Street and north on Lincoln Avenue, in the northwest section of Pasadena, instead of the proposed line to run the length of Lincoln Avenue, is reported to be the plan of H. E. Huntington.

Lewiston, Idaho.—The bonus of $50,000 to be paid Z. A. Johnson when the electric road is completed from Nez Perce to connection with the Grangeville line is now assured and necessary notes will be deposited in the Grangeville Bank before the end of the week. It is expected that grading will commence within two weeks.

Long Beach, Cal.—The Pacific Electric, which owns a franchise from this city to West Long Beach, has been asked by the Board of Public Works to consent to a change in its tracks on Railroad Avenue, in West Long Beach, to the 40-foot street north of the Salt Lake tracks, in order to make a good thoroughfare for travel. Engineer Bell approves the plan, but has referred it to Mr. Huntington for final decision.

Los Angeles, Cal.—P. D. Noel has filed in the Superior Court an injunction suit against the city to restrain the sale of a franchise on July 27th for a cable incline railway to run from Marmion Way to West Avenue 43, as provided by the city ordinance of June 15th. Mr. Noel states that he is a landowner in the region affected and that the construction of the railway will cut off access to his land and to land of others.

Oakland, Cal.—The S. F., O. & S. J. Consolidated Railway Company has filed its application with the City Council for permission to construct and operate an electric line along Poplar Street from the present Twenty-second Street line to Court Street. The company has already purchased a piece of property at Twelfth and Poplar Streets where in the near future it will commence the construction of a station in case its present application meets with favorable action.

Gridley, Cal.—The citizens of Gridley have about completed arrangements whereby the Northern Electric will build a spur into that city. The proposed route is through the colonies, to the south of the county road, to the cannery grounds. A spur will also be run to the cannery building, so that fruit shipped from the orchards can be unloaded at the building. It is understood that this extension will be commenced very soon, in order to handle this season's crop of peaches and late fruits.

Alameda, Cal.—At a conference last week between Assistant General Manager W. R. Scott of the Southern Pacific and the City Council of Alameda, all the details in connection with the railroad's application for electric franchises in Alameda were gone over and practically settled. Negotiations progressed so far that the committee of the whole of the Council announced that, if the law did not prevent, the franchises would be granted at a special Council meeting. If the franchises cannot be granted at the special meeting they will be granted at the next regular meeting on July 20th. The change will include an interurban street car service between Alameda and Oakland, as well as an electric service between Alameda and San Francisco. Mr. Scott announced that a regular street car service would be maintained to Oakland, via the Eighth Street cut-off, which is to link the Lincoln and Encinal Avenue lines at the West End. The railroad officials also say that several new stations will be added and that all of the present stations will be maintained and that the 2½ cents local fare now in effect within the limits of Alameda will be maintained. The company agrees to light all stations and crossings.

INCORPORATIONS.

Bakersfield, Cal.—The U. S. Water Company has been incorporated with a capital stock of $10,000 by J. M. Danziger, W. Mongrage and A. W. Brooms.

Eureka, Cal.—The Trinidad Water Company has been incorporated here with a capital stock of $25,000 by C. A. Kallstrom, G. M. and Emma Scott; place of business, Trinidad.

Riverside, Cal.—Articles of incorporation of the Alamo Water Company have been filed. The company is organized for the purpose of purchasing from the Riverside Land & Irrigation Company an acre and one-half of land at North Almond and Santa Ana Streets, including well, etc., and for acquiring water.

WATERWORKS.

Salt Lake City, Utah.—Acting Mayor Davis has signed the resolution awarding the contract for laying 21,000 feet of water mains during 1908, to J. D. Hanley.

Phoenix, Ariz.—The contract for the new pumping plant which is to furnish water for the new union high school has been awarded to the O. S. Stapley Hardware Company.

Redwood, City, Cal.—The City Trustees have laid out improvements for the municipality for which they expect to expend $30,000 shortly, $10,000 to be devoted to improving the water system.

San Juan, Cal.—The Board of Trustees has received a report to the effect that the cost of the system from Pearce's Spring through the town and of building a reservoir on Ramona Heights would be $9200.

Bisbee, Ariz.—The Huachuca Water Company's plant has been sold under foreclosure and was bid in for the amount of the judgment. The company will now be reorganized and the new company will immediately take over the plant.

San Francisco.—Miller & Lux have filed a petition with the Board of Supervisors, asking for permission to lay a 6-inch pipe line for the purpose of carrying water, and also to erect poles and to string wires for the transmission of power.

Jackson, Cal.—The trustees have authorized the president of the Board to sign an agreement executed on behalf of the city with the Argonaut Mining Company, in relation of right of way to lay water pipe through the company's land.

Oakland, Cal.—The Auditing and Finance Committee of the City Council has recommended the appropriation of $499 for the purpose of erecting an additional salt water pumping plant on the shores of Lake Merritt at the foot of Wayne Avenue.

San Diego, Cal.—The city will spend $15,353.04 in improvement of the water system. The Board of Public Works is authorized to advertise for bids for the proposed improvements, which will include an entirely new pipe line in the University Heights section of the city.

Williams, Ariz.—The Grand Canyon Electric Light and Power Company has applied to the City Council for a franchise to maintain and operate pipes, mains and laterals upon all of the public streets of this town, and to construct, maintain and operate an electric light power plant in this city.

Oroville, Cal.—The Oro Water, Light & Power Company has distributed cast-iron pipe on Bird Street, which the company's officials state marks the beginning of the general overhauling of the distributing system in this city. It is stated that approximately $40,000 is to be expended in making the changes.

Redding, Cal.—Judge Head of the Superior Court has decided a novel lawsuit in favor of the farmers on Cow Creek. The Northern Light & Power Company brought suit to condemn their water rights on Old Cow Creek. Judge Head decided today that riparian rights could not be condemned for such a public service corporation as a power company. This is the first time such an issue has been before a California court.

San Francisco.—Colonel Joseph W. Duncan, Colonel John B. Bellinger and Lieutenant Oliver P. M. Hazard will leave early in July for Atascadero. They go to prepare the maneuver grounds and to install a water system for the accommodation of troops. The water supply is adequate and formed one of the most advantageous features of the Atascadero property, as it was supplied at the time of the maneuvers in 1904 and has remained in readiness ever since.

San Rafael, Cal.—A movement toward public water ownership by San Rafael and the other Southern Marin towns was inaugurated when the Board of Trustees of San Rafael made arrangements to hire an expert to estimate the cost of a municipal distributing system for San Rafael to take the place of the present one. When such an estimate is made, the two water companies will be asked to name the figure on which they will negotiate the sale of their several properties.

San Francisco.—Between two and a half and three million dollars will be saved, City Engineer Manson states, in the construction of the distributing pipe lines to be laid in this city for the proposed Sierra water system by the mains of the auxiliary system for fire protection. With a single pipe system such as the Spring Valley maintains throughout the city, it is necessary that the mains be sufficiently large to meet fire emergency demands as well as private supply. With the auxiliary fire protection system in place and effectually safeguarding fifty per cent of the city's territory, the municipal system will not need the larger mains. Instead of eight-inch, five or even four-inch mains may be used. For fire protection at higher levels of the city Engineer Manson plans to locate on convenient, highly elevated sites reservoirs of from 3,000,000 to 10,000,000 gallons' capacity, the water to be used primarily for general domestic purposes, but also for fire by a system of comparatively large mains.

ILLUMINATION.

San Francisco.—Contracts have been awarded by the Harbor Commission for Herzog & Dahl for installing electric lighting plants on the State tugboats, Governor Irwin and Governor Markham, for $2750.

Azusa, Cal.—The Chamber of Commerce held a special meeting last Thursday and selected the following committee to confer with the Interstate Gas Company relative to piping gas to Azusa: Dana C. King, W. R. Powell, H. M. Couler, J. H. Anderson and W. S. Stevens.

Los Angeles, Cal.—The Pacific Light & Power Co. will buy the plant of the City Gas Company. One of the details is said to be that the Pacific Light & Power Co. stands ready to pay for the gas company holdings in bonds of the power company, giving the gas promoters a profit of $200,000 or more, the bonds being guaranteed worth par after a certain period. It is practically assured that the deal will be concluded within a short time. Officials of the Los Angeles Gas & Electric Co. profess to have no interest in the pending deal. They say they have no object in buying out their new competitor.

Oakland, Cal.—The indictments against J. B. Allen, Dr. Bardach and M. F. Allen of the Oakland Transcontinental Aerial Telephone and Power Company, who were charged with using the mails for a scheme to defraud, have been dismissed.

FINANCIAL.

Santa Barbara, Cal.—An election will be held July 22nd to vote on a bond issue of $200,000 for a water system.

Visalia, Cal.—Assessment No. 2 of one mill per share on the stock of the Visalia Non-Assessable Oil Co. is delinquent July 18.

Wasco, Cal.—The Fourth Extension Water Company has levied an assessment of $1.00 per share delinquent August 1st; sale day, August 17th.

Los Angeles, Cal.—A trust deed of the American Petroleum Co. to the Southern Trust Co. for $2,000,000, to cover the cost of development work, has been filed in this city. The loan bears 6 per cent interest.

Napa, Cal.—The Sheriff has placed an attachment upon the plant of the Calistoga Electric Light & Power Co., at the instance of San Francisco creditors. Recently the plant was levied upon in several suits commenced by Harry G. Brown, president of the defunct Bank of Calistoga. This litigation is still pending.

Boston, Mass.—The Boston Stock Exchange has listed the 61,162 outstanding shares of the Pacific Coast Power Company, of Washington, which has a capital of $7,000,000. The company's officers are: President, Frank Dabney; treasurer, Henry B. Sawyer; secretary, Alvah K. Todd. This is a Stone & Webster property.

Los Angeles, Cal.—Information has been issued to the stockholders of the Union Oil Company relative to the action of directors at the recent meeting when the proposition of raising the capitalization from $10,000,000 was favorably acted upon. It is proposed to issue three shares for one to stockholders of the Union and Union Provident Companies. The stockholders will vote on the matter at the next meeting, August 20th.

Bakersfield, Cal.—The Topax Oil Company, composed of local capitalists, which will begin development in the Sunset field, has been organized, with a capital of $50,000, with $10,000 paid in. The company will do development work on the southeast corner of Section 12 and the northwest corner of Section 18. It has possession of forty acres of proven valuable oil land, and on the section line is a 100-barrel well of fine 19 gravity oil. The stockholders in the new company are: C. W. Ball, J. H. Sheridan, R. G. Avery, C. A. Metcalfe, Chas. Dickinson, Harry W. Thomas, T. M. Young, O. McReynolds, Chas. Hill, D. McFarland, Phil Blankenship, Dr. W. S. Fowler, Ira Hochheimer, Messrs. Inglis, Stevens and Wallace. The directors are J. H. Sheridan, O. McReynolds, Robert H. Avery, H. W. Thomas and Chas. Ball.

San Francisco.—In the suit of the San Joaquin and Kings River Canal and Irrigation Company against the County of Stanislaus to restrain the Board of Supervisors from enforcing the irrigation water rates imposed in 1897, Judge Morrow granted a temporary injunction in which he decided some of the points at issue in the present controversy between the Spring Valley Company and the city of San Francisco. He declares that the questions involved cannot be solved until a full and accurate investigation has been held. He takes the stand, however, that if a great injury would be done the petitioner and an injunction would cause small inconvenience to the other party, the temporary restraining order should be granted pending the inquiry into the full merits of the case. While not positive on the subject, the decision leans toward the proposition that an allowance should be made for depreciation and that the capital actually invested should be taken into account in determining values.

San Francisco.—Bonds of the California Gas and Electric Company, amounting to $4,000,000, have been sold to a syndicate of Eastern capitalists. The bonds carry five per cent interest and were taken at 90 and 91. They run for thirty years. The capitalists are: Stedman Bullock and J. E. Oldham, of Boston; R. Walter Levy and Allen G. Hoyt, of New York; E. P. Russell, H. B. Judson, L. A. Walton, M. N. Mayer, J. A. Scudder, H. T. Libley, J. C. Craft, H. L. Steuart, M. E. Simond, of Chicago; E. T. Morris, of Bay City, Mich.; L. H. Kirby and A. B. Connable, of Kalamazoo, Mich.; A. B. Bishop, of Flint, Mich.; J. C. Copley, of Aurora, Ill.; Howard J. Lesher, John W. Anderson, George O. Begg, George Wiley, H. F. Fox, Theodore Luce, J. R. Bodde and William E. Reilly, of Detroit, and John Nickerson, Jr., of St. Louis. A part of the $4,000,000 will be used to take up the floating indebtedness and the remainder will be used for the extension and enlargement of the company's power plants located in the various parts of the State.

TELEPHONES.

Bakersfield, Cal.—At a meeting of the Kern Mutual Telephone Company, which is to establish telephonic communication with the West Side oil fields, C. S. Garfield was elected to membership on the board of directors in place of Frank G. Munzer, who has resigned. It is announced that the construction of the new system will begin shortly.

San Francisco, Cal.—The Western Pacific will not use the telephone in connection with the operation of its trains, but will adhere to the telegraph. Orders have been received from headquarters to commence the erection of poles along the line, and as these have been stored for some time, it will not take long to put them in place.

El Centro, Cal.—An Imperial Valley branch of the Home Telephone Company has been organized. The purpose of the company is to stretch telephone lines directly to San Diego from the principal cities of Imperial Valley, which will give this city cheaper and better telephone service to that region. A second line will also be constructed from Calexico to Redlands, where the Home company connects directly with Los Angeles. At a meeting of the directors of the company in Imperial Valley it was decided to commence the construction of the lines direct to the coast as soon as the heated term passes. One thousand miles of telephone lines are to be constructed by the newly organized Home company, which is incorporated for $50,000. J. Fred Stadt, Brawley; W. A. Edgar, Imperial; Fritz Klokke, Calexico; F. S. Webster and Dr. R. P. Shepard, El Centro; J. M. Baldwin, Monrovia, and H. C. Goldrick, San Francisco, were appointed directors.

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Conduit Fixtures
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Standard Electrical Works.
Sterling Electric Co.

Cooling Towers
O. C. Goeriz & Co.
Moore, Chas. C. Co., Inc.
Tracy Engineering Co.

Cross Arms
Electric Appliance Co.
Sterling Electric Co.

Dynamos and Motors
Brooks-Follis Elec. Corp.
Crocker-Wheeler Co.
Electric Appliance Co.
Fort Wayne Electric Works
General Electric Co.
Northern Elec. Mfg. Co.
Standard Electrical Works
Sterling Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Elevators
Van Emon Elevator Co.

Electric Grinders
General Electric Co.
Northern Electrical Mfg. Co.
Standard Electrical Works.
Western Electric Co.

Electric Heating Devices
Electric Appliance Co.
General Electric Co.
Johns-Manville Co., H. W.
Standard Electrical Works.
Vulcan Electric Heating Co.

Electrical Instruments
Cutter Co., The
Electric Appliance Co.
Fort Wayne Electric Works
General Electric Co.
Johns-Manville Co., H. W.
B. F. Kieruliff, Jr. & Co.
Sterling Electric Co.
Westinghouse Elec. & Mfg. Co.
Weston Elec. Instrument Co.

Electrical Machinery
Crocker-Wheeler Co.
Electric Appliance Co.
General Electric Co.
Northern Electrical Mfg. Co.
Standard Electrical Works
Sterling Electric Co.
Western Electric Co.

Electric Polishers
Northern Electric Mfg. Co.

Electric Railway Appliances
Pierson, Roeding & Co.
General Electric Co.
B. F. Kieruliff, Jr. & Co.
Johns-Manville Co., H. W.

Electrical Supplies
Brooks-Follis Elec. Corp.
Chase-Shawmut Co.
Electric Appliance Co.
General Electric Co.
Northern Electrical Mfg. Co
Standard Electrical Works
Johns-Manville Co., H. W.
Sterling Electric Co.
Westinghouse Elec. & Mfg. Co.
Western Electric Co.

Electric Ventilating Fans
General Electric Co.
Northern Electrical Mfg. Co.
Standard Electrical Works.
Sterling Electric Co.
Western Electric Co.

Engines, Boilers, Heaters, etc.
Moore, Chas. C. Co., Inc.

Engineers, Chemical
Moore & Co., Chas. C., Inc.
Smith, Emery & Co.
Standard Electrical Works
Tracy Engineering Co.
Westinghouse Machine Co.

Engines, Gas and Gasoline
Moore & Co., Chas. C., Inc.
Westinghouse Machine Co.

Engineers and Contractors
Brooks-Follis Elec. Corp.
Cory, C. L.
Copeland, Clem A.
Goeriz & Co. O. C.
General Electric Co.
Jackson, D. C. & W. B.
Moore, C. C. & Co., Inc.
Smith, Emery & Co.
Standard Electrical Works.
Sterling Electric Co.
Thaxter, H. C.
Tracy Engineering Co.
Van Norden, Rudolph W.
Western Electric Co.
Westinghouse Elec. & Mfg Co.

Feed Water Heaters and Purifiers
Moore, Chas. C. Co., Inc.
Tracy Engineering Co.
C. H. Wheeler Mfg. Co.

Fire Proofing
Johns-Manville Co., H. W.

Fuses and Fuse Devices
Chase-Shawmut Co.
Electric Appliance Co.
General Electric Co.
Johns-Manville Co., H. W.
Standard Electrical Works.

Ground Connection Clamps
Chase-Shawmut Co.

House Goods
Electric Appliance Co.
Partrick, Carter & Wilkins Co.
Standard Electrical Works.

Hydraulic Machinery
Goeriz & Co., O. C.
Moore, Chas. C. Co., Inc.
Pelton Water Wheel Co.
Standard Electrical Works.
Tracy Engineering Co.

Injectors
Vulcan Iron Works

Insulators and Insulating Material
Bossert Elec. Cons. Co.
Brooks-Follis Electric Co.
Electric Appliance Co.
Fort Wayne Electric Works
General Electric Co.
Johns-Manville Co., H. W.
Lima Insulator Co.
Okonite Co., Ltd.
Pierson, Roeding & Co.
Standard Electrical Works.
Standard Undergrnd Cable Co.
Sterling Electric Co.
Thomas Insulator Co.
Western Electric Co.

Lamps, Arc
Benjamin Electric Mfg. Co.
Electric Appliance Co.
Fort Wayne Electric Works
General Electric Co.
Standard Electrical Works
Sterling Electric Co.
Western Electric Co.
Westinghouse Elec. & Mfg. Co.

Lamps, Incandescent
Bryan, Marsh Co.
Electric Appliance Co.
California Incand. Lamp Co.
Holabird-Reynolds Elec. Co.
Johns-Manville Co., H. W.
General Electric Co.
Standard Electrical Works
Sterling Electric Co.
Western Electric Co.

Line Material
General Electric Co.
Johns-Manville Co., H. W.
Standard Electrical Works.

Meters, Electric
Duncan Elec. Mfg. Co.
Electric Appliance Co.
General Electric Co.
Johns-Manville Co., H. W.
B. F. Kieruliff, Jr. & Co.
Standard Electrical Works.
Westinghouse Elec. & Mfg. Co.

Meters, Gas
Pacific Meter Co.

Mining Machinery
Moore, Chas. C. Co., Inc.

Motors
Crocker-Wheeler Co.
Electric Appliance Co.
Fort Wayne Electrical Works
General Electric Co.
B. F. Kieruliff, Jr. & Co.
Northern Electric Mfg. Co.
Pierson, Roeding & Co.
Standard Electrical Works
Sterling Electric Co.
Western Electric Co.

Nipples
Chase-Shawmut Co.

Outlet Blocks
Chase-Shawmut Co.

Outlet Bushings and Locknuts.
Chase-Shawmut Co.

Paint, Insulating
Paraffine Paint Co.
Standard Electrical Works.

Pins
Benicia Iron Works

Pipe
Pierson, Roeding & Co.
Schaw-Batcher Co., The

Pipe and Boiler Coverings
Johns-Manville Co., H. W.

Poles, Ties, Brackets, etc.
B. F. Kieruliff, Jr. & Co.
Barnes-Lindsley Mfg. Co.

Pole Lines
Pierson, Roeding & Co.
Benicia Iron Works.

Power Plants
General Electric Co.
Moore & Co., Chas. C., Inc.
Standard Electrical Works.
Tracy Engineering Co.

Pumping Machinery
Moore, Chas. C. Co., Inc.
Tracy Engineering Co.

Pumps, Centrifugal
Moore, C. C. & Co., Inc.

Pumps—Air Lift and Artesian
Hunt, Mirk & Co.

Pumps, Steam
Moore, Chas. C. Co., Inc.
Tracy Engineering Co.

Rail Bonds
Chase-Shawmut Co.
B. F. Kieruliff, Jr. & Co.
Pierson, Roeding & Co.

Solder Paste.
Chase-Shawmut Co.
Standard Electrical Works.

Steam Engines
Tracy Engineering Co.

Stage Lighting Fittings.
Chase-Shawmut Co.

Steam Plant Equipment
Tracy Engineering Co.

Steam Boilers
Moore & Co., Chas. C., Inc.
Standard Electrical Works.
Tracy Engineering Co.

Steam Packing
Johns-Manville Co., H. W.

Storage Batteries
Electric Storage Battery Co.

Switch Boxes
Electric Appliance Co.
Standard Electrical Works.

Switches
Bossert Elec. Cons. Co.
Electric Appliance Co.
General Electric Co.
B. F. Kieruliff, Jr. & Co.
Standard Electrical Works
Westinghouse Elec. & Mfg. Co.
Sterling Electric Co.
Western Electric Co.

Tape
Electric Appliance Co.
General Electric Co.
B. F. Kieruliff, Jr. & Co.
Okonite Co., Ltd.
Standard Electrical Works
H. W. Johns-Manville Co.

Telegraph Apparatus
Sterling Electric Co.

Telephones and Supplies
Brooks-Follis Elec. Corp.
Electric Appliance Co.
B. F. Kieruliff, Jr. & Co.
Sterling Electric Co.
Standard Electrical Works
Western Electric Co.

Tested Fuse Wire and Links.
Chase-Shawmut Co.
Standard Electrical Works.

Test Lamps, Pocket
Chase-Shawmut Co.

Transformers
Crocker-Wheeler Co.
Electric Appliance Co.
Fort Wayne Electric Works
General Electric Co.
Standard Electrical Works
Westinghouse Elec. & Mfg. Co.
Sterling Electric Co.
Western Electric Co.

Traps, Steam
Moore, Chas. C. Co., Inc.

Valves
Moore & Co., Chas. C., Inc.
Standard Elec. Works

Water Wheels
Pelton Water Wheel Co.
Moore, C. C. & Co., Inc.

Water Wheel Governors
Pelton Water Wheel Co.
Pierson, Roeding & Co.

Wires and Cables
Electric Appliance Co.
General Electric Co.
Habirshaw Wire Co.
Indiana Rubber & Insulated Wire Co.
B. F. Kieruliff, Jr. & Co.
New York Insulated Wire Co.
Okonite Co., Ltd.
Nat. Conduit & Cable Co., The
Simplex Electrical Co., The
Sterling Electric Co.
Standard Electrical Works.
Standard Undergrnd. Cable Co.
Western Electric Co.